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PETROLOGY.—*Microscopic examination of clays.* R. E. SOMERS, Cornell University. (Communicated by David White.)

Most of the clays referred to in this report were examined microscopically in order to determine the minerals contained in them, and in addition thin sections of some of the burned samples were studied so far as time would permit in order to obtain some idea of the changes that took place in burning.

The investigation is not to be regarded as an exhaustive one, as much still remains to be done along this line, but so far as it went, it is thought that the results are of interest.

Table 1 gives the minerals that were noted in the different specimens examined, and also their approximate abundance.

IDENTIFICATION AND CHARACTER OF MINERALS

Quartz.—When in medium or coarse grains, quartz can be readily discriminated by means of its index of refraction, low interference color, and lack of cleavage. There are no other minerals in clays which resemble it under these conditions. When, however, it is in small grains, it greatly resembles kaolinite. Its index of refraction is then of little assistance, the interference color is lowered to about that of the kaolinite, and its determination has to depend upon its more angular shape and its more rapid extinction, or "quicker wink." Such grains are generally too small to make use of the difference in optical character.

While quartz was noted in many of the clays examined, it was particularly abundant in the residual ones. Most of the Wilcox clays from the Embayment area showed but little.

Kaolinite.—This can be distinguished by its orthodox charac-

TABLE 1

THE COMPOSITION OF CLAYS

Formation and locality[a]	Quartz	Hydromica	Kaolinite	Rutile	Zircon	Tourmaline	Epidote	Titanite	Diaspore	Halloysite	Colloid matter
RESIDUAL CLAYS											
From Granite											
English china clay, washed	S[b]	M	VA								
From Cambrian sandstone (Chikies)											
Frazer, Pa.	A	M	A	C							
From Cambrian schist											
Mt. Holly Springs, Pa., Sandusky Port. Cem. Co.	C	C	A	C							
Mt. Holly Springs, Pa.	C	A	VA	C		S					
Mt. Holly Springs, Pa., Phil. Clay Co.	A	A	A	C		S					
Mt. Holly Springs, Pa., washed, Phil. Clay Co.	C	C	A	S		S					
Mt. Holly Springs, Pa., Holly Clay Corp'n	C	C	A	S	S	S					
Mt. Holly Springs, Pa., washed, Holly Clay Corp'n	M	C	VA	C			S				
Beavertown, Pa.	C	S	VA		S						
Narvon, Pa., Whittaker pit	S	A	A	S	S	C					
Narvon, Pa., Diller pit	A	A	A	C	S	S	S	S			
From Cambrian (Chikis quartzite)											
Honey Brook, Pa.	VA	C	S	C		S					
From Cambrian (Gatesburg) clayey sandstone											
Scotia Centre, Pa.	S	A?	C?	S	S	S					
Warriors Mark, Pa.	A	S	VA	A		S		C?			
Furnace Road, Pa., Colonial Clay Co.	A	S	A	C	S						
From Cambrian shale											
Cold Spring, Va.		S	A	A	S	S					
From Cambrian limestone											
Lutesville, Mo.	A	A	A								
Lutesville, Mo., No. 1 clay	C	A	A	S			S				
Lutesville, Mo., No. 2 clay	C	C	A	A		S	S				

[a] The minerals listed here represent the identifiable grains, but some of them contain a variable quantity of exceedingly small grains not identifiable, and which are indicated in the column headed Colloid matter. Aside from this, most of the clays undoubtedly contain colloidal particles so small as not to be visible with the ordinary microscope.

[b] S, scarce; C, common; M, moderate amounts; A, abundant; V A, very abundant.

From Oriskany shales, limestones and sandstones										
Kunkletown, Pa., disintegrated quartzite	A		S	S						
Kunkletown, Pa., clay with quartzite	C	C	A	A		S				
Kunkletown, Pa., clay with quartzite, washed	C	C	A	C						
Saylorsburg, Pa , Crude No. 1	A	A	A	A		S		S		
Saylorsburg, Pa., Crude No. 2	C	A	A	A			S			
Saylorsburg, Pa. washed	C	A	A	S						
Saylorsburg, Pa., Crude, Cement Company's mine	C	C	A	A	S	S				
Shirleysburg, Pa.	S	C	A	A	S					
MISCELLANEOUS RESIDUAL CLAYS										
Bauxite, Ark., banded clay under bauxite		S	VA	A			S	S		
Bauxite, Ark., white clay under bauxite		S	VA	S	S					
(Both have some large flakes of mica)										
Oreana, Nev., Pitt-Rowland deposit	A	A[c]	A	S			S			
Lovelocks, Nev., Adamson-Dickson deposit	A		A	S						
Beatty, Nev., Bond-Marks deposit			S	S					VA	
Antioch, Calif.	S	S	VA	S		S				M?
Fort Payne, Ala., Brower Mine	C	A	A	A		S				
Fort Payne, Ala., Cochrane pit. Siliceous bauxite	S	C		A	S	S				A
Fort Payne, Ala., Cochrane pit, bauxite		S	M	A	S					VA
Bynum, Ala., Kraus pit, white clay		A	A	S		S				
Bynum, Ala., Kraus pit, black clay		C		C	S					A
SEDIMENTARY CLAYS										
Carboniferous										
Cheltenham Clay, St. Louis dis., Mo.										
Raw washed pot clay, LaClede-Christy	C	A	A	S						
Weathered pot clay, LaClede-Christy	C	A	C	A	S	S				
Fire-brick clay, LaClede-Christy	C	A	S	S				S		
Selected crude clay, LaClede-Christy	C	A	S	S						
Weathered pot clay, Highland Clay Co.	S	A	A	S	S					
Washed pot clay, Highland Clay Co.	C	A	C	A			S			
Indianaite, Huron district, Indiana										
Earthy white clay		A	A	S					C	
Massive white clay		S	C	C					A	
Flint Clay district, Central Missouri										
Plastic clay, Bland, Mo.	A	C	S							
White clay, Owensville, Mo., Sassman pit		S	S	S						C
Red clay, Owensville, Mo., Sassman pit			S	C						C

[c] Probably mostly sericite.

Flint clay, Owensville, Mo., Sassman pit			S	C						C
Flint clay, Hofflins, Mo., Cox pit		S		S	S	S				C
Flint clay, Hofflins, Mo., Cox pit		S	VA	A	S	S			S	
Flint clay, Owensville, Mo., Connell pit		C	A	S					C	
Flint clay, Rosebud, Mo., Toelke and Heidel pit			C	A					A	
Diaspore clay, Rosebud, Mo., Brown pit				S	S				VA	C?
Diaspore clay, Owensville, Mo., Connell pit			C	S					C	C
Diaspore clay, Rosebud, Mo., Brown pit			C	S					VA	
Diaspore clay, Owensville, Mo., Sassman pit	S		A	A		S			C	
Diaspore clay, Owensville, Mo., Connell pit			A	S	S				A	
Lower Cretaceous										
White clay, Gordon, Ga., upper bed, Col. Kaol. and Alum. Co.	C	C	A	S						M
Nodular clay, Gordon, Ga., upper bed, Col. Kaol. and Alum. Co.	S		S	S	S					VA
White clay, Dry Branch, Ga., crude, Amer. Clay Co.	S	C	VA	S						
White clay, Dry Branch, Ga., washed, Amer. Clay Co.	S	C	A	S	S					
Allendale, S. Ca., Box pit										
Abbeville, S. Ca., Hill pit	S	S	A	C	S					
White clay, S. W. of Trenton, S. Ca.	A	C	A	S						
Bath, S. Ca. McNamee Kn. Co., 1	C	S	VA	A			S			
Bath, S. Ca. McNamee Kn., Co., 2		M	A	A	S					
White clay, Langley, S. Ca.		C	A	A	S	S				
White clay, Langley, S. Ca.	S	C	VA	A		S				
Upper Cretaceous	S	C	A	A	S			C		
Rayflin, S. Ca., Edisto Kaolin Co.	A	S	A	S	S		S			
White clay, Aiken, S. Ca.	S	S	A	A						
Ripley										
White clay, Perry, Ga., Houston Kaolin Co.	S	S	S	C	S			S		A
White part of mottled clay, Perry, Ga., Houston Kaolin Co.		S	S	S	S	S		S		A
Red part of mottled clay, Perry, Ga., Houston Kaolin Co.	S	S	S	S	S	S				A[d]
Sagger clay, Hollow Rock, Tenn.	C	A	C	C		S				
Sagger clay, Hollow Rock, Tenn.	C	A	A	A	S					
Lignitic clay, India, Tenn.	S	A	C	S						
Brown sandy clay, E. Paris, Currier pit	C	A	A	A		S		S		
Dark clay, E. of Paris, Currier pit	C	A	C	S						

[d] Stained with hematite.

Porter's Creek											
Wad clay, Benton, Ky., Howard pit	C	A	A	A			S				
Wad clay, Benton, Ky., Howard pit	C	A	A	A							
Wad clay, Briensburg, Ky.	C	A	A	S	S						
Wilcox formation											
Andersonville, Ga., Sweetwater mine, white clay		C	A	S							
Andersonville, Ga., Sweetwater mine, mottled clay		S	A	S	S						M?
Enid, Miss., No. 5 pit, Bramlett	C	VA	S	S		S					
Enid, Miss., No. 21 pit, Bramlett	S	A	A	S		S					
Holly Springs, Miss., stoneware clay	C	A	A	C							
Lagrange, Tenn., Dale sand pit, claylens	A	S	A	M	S	S		S			
Lagrange, Tenn., McAnee pit	C	A	A	A	S						
McKenzie, Tenn., No. 10 ball, Johnson-Porter	S	A	A	S		S					
McKenzie, Tenn., No. 11 ball, Johnson-Porter	S	A	A	S							
McKenzie, Tenn., Sparks pit	S	A	A	M		S	S				
Sagger clay, Henry, Tenn., Chrisman and Reynolds	A	A	C	C	S	S					
1 S. G. P. clay, Whitlock, Tenn., Mandle	S	A	C	C		S					
No. 5 Ball, Whitlock, Tenn., Mandle	S	A	C	S							
No. 7 Ball, Whitlock, Tenn., Mandle	S	A	C	S							
No. 4 Ball, white, Whitlock, Tenn., Mandle	S	A	C	A		S					
No. 4 Ball, dark, Whitlock, Tenn., Mandle	S	A	C	S							
Puryear, Tenn., Dixie Brick & Tile Co.	C	C	VA	S	S	S		S			
Wad clay, Hazel, Ky., Cooley Ball and Sagger Clay Co.	C	C	A	C		S					
Dark ball clay, Hazel, Ky., Cooley Ball and Sagger Clay Co.	S	A	C	A	S						
No. 4 Ball, Pryorsburg, Ky., Ky. Constr. & Imp. Co.	S	VA	A	S							
Old No. 4 Ball, Pryorsburg, Ky., Ky. Constr. & Imp. Co.	S	VA	C	A							
No. 5 clay, Pryorsburg, Ky., Ky. Constr. & Imp. Co.	S	C	A	M							
No. 3 Ball, Pryorsburg, Ky., Mayfield Clay Co.	C	VA	A	S		S					
Ball, Pryorsburg, Ky., Mayfield Clay Co.	C	A	A	A		S					
No. 1 Ball, Hickory, Ky., Old Hickory Clay & Talc Co.	S	VA	C	S							
Crude clay, Lester, Ark., Camden Coal and Clay Co.	C	A	A	A	S	S		S			
Washed clay, Lester, Ark., Camden Tertiary	A	A	C	S		S					
Crude, Edgar, Fla.	A	S	A	S	S						
Washed, Edgar, Fla.	S	A	A	S	S						

ters when of larger size, combined with its flaky nature and very often its tendency to combine in fan- or worm-shaped bunches. Low index of refraction and low birefringence separate it from the other micaceous minerals. When fine, it can merely be noted as minute, transparent plates, of an index of refraction close to the balsam, and very low interference color.

The kaolinite occurs as single scales or plates, sometimes in bunches of fan-shaped character, and as vermiculites. In one clay, the Indianaite from Lawrence County, Indiana, spherulite-like bodies were also found.

Specially fine examples of "fans" were noted in the clay from Perry, Georgia, Bynum, Alabama, Bauxite, Arkansas, and Antioch, California.

Good examples of vermiculites were seen in samples from South Carolina, Perry, Georgia, Bauxite, Arkansas, Antioch, California, and the nodular white clay from Gordon, Georgia.

The Florida clay from Okahumpka and Edgar, as well as the samples from Langley and Aiken, South Carolina, showed large single flakes.

Hydromica.—This is a distinctly micaceous mineral, which has single and double refractions higher than those of kaolinite, yet not so high as muscovite or sericite. Furthermore, the degree of these refractions varies in different clays. It is therefore assumed[1] that there is an isomorphous gradation between sericite and kaolinite, with a gradual loss of potash and addition of water, and, in weathering products such as these, hydromica represents a transition stage of weathering toward kaolinite as the final product.

The fan of the hydromica is similar to that of the kaolinite, but it may occur in larger grains. Radiating bunches and spherulite-like grains were found in the white clay from near Huron, Indiana.

COMPARATIVE ABUNDANCE OF KAOLINITE AND HYDROMICAS

Descriptions of the microscopic examination of clays that have appeared from time to time, make frequent reference to kao-

[1] For discussion of hydromica see GALPIN, SYDNEY L. *Studies of flint clays and their associates.* Trans. Am. Ceram. Soc. 14: 306 and 338.

linite, but the presence of mica is less often commented on, and yet, judging from the nature of the clays described in this report, it seems to be quite abundant.

The same might possibly be inferred from the chemical composition of many kaolins which show a small percentage of potash, for since feldspar seems to be very scarce, the former may be regarded as belonging to mica.

Vogt, for example, in 1906, concluded that china clay consisted of kaolinite, muscovite, and quartz, although he based his conclusions on the chemical composition of the material.[2]

Later, Hickling,[3] after studying the china clay of Cornwall, states that in the finest washed clays, kaolinite, mica, quartz, and tourmaline are present, but that the first two make up 90 per cent of the mass. He adds, however, that the relative amounts of kaolinite and muscovite are difficult to estimate.

He differentiates the mica into two classes, *viz*, primary mica and secondary mica derived from feldspar.

He refers to the kaolinite as occurring as irregularly hexagonal prisms, with rough faces, which show strong transverse striations corresponding to the basal cleavage. "These prisms are usually curved, sometimes quite vermiculiform. The shorter prisms commonly present a fanlike arrangement and exactly resemble the similar forms of mica, from which they can be distinguished only by their lower interference tint."

Isolated plates or very short prisms may occur, and then "even with convergent polarized light, it is not easy to judge the amount of birefringence under such circumstances, and, consequently, to decide to which mineral a given fragment belongs; hence the difficulty of estimating their relative proportions. Both kinds show the same irregular form (due probably to development within decaying feldspars) and the same evidence of corrosion on the edges. The low interference-tint and low index of refraction definitely distinguish these crystals from mica.

[2] VOGT, G. *De la composition des argiles.* Memoires publiés par le Societé d'Encouragement pour l'Industrie Nationale, Paris, 1906, pp. 193–218.

[3] HICKLING, G. *China clay. Its nature and origin.* Trans. Inst. Min. Eng. 36. 1908–09.

The identification of kaolinite rests on the following evidence:

(*a*) The index of birefringence is distinctly low, about that of quartz, but variable.

(*b*) The index of refraction is very near to 1.56.

(*c*) The prismatic crystals extinguish parallel to the basal plane.

(*d*) Basal flakes show a biaxial interference figure.

While Hickling refers to the mica as muscovite, he notes that it may be hydrated; indeed he thinks that the muscovite changes directly to kaolinite in the clay, because: 1. He can find mica but no kaolinite in feldspar or in the granite. 2. There is no difference in form between the mica and kaolinite. 3. He finds prisms which are mica at one end and kaolinite at the other.

He also quotes the observations of Johnstone,[4] who found that by exposing muscovite to pure water, and water saturated with CO_2, for 12 months, it had changed to hydromuscovite. This Hickling believes shows a conversion in the direction of kaolinite.

In line with these observations, reference may be made to the work of Galpin[5] on flint clays. In these he found platy masses of what at first appeared to be kaolinite, which frequently show "ribs" or plates of higher index and birefringence intergrown with those of kaolinite, and which ribs show practically every grade of variation between kaolinite and muscovite.

Halloysite.—Two clays, *viz*, those from north of Huron, Indiana, and the Bond-Marks deposit near Beatty, Nevada, contain material in platelike grains, which is isotropic, and is probably to be regarded as halloysite. In no other samples could this material be so definitely identified.

Rutile.—The presence of rutile is interesting, in view of the probable constant occurrence of titanium in high-grade clays. Practically every clay examined shows rutile in some amount. In some cases it is in grains or prisms, perhaps 0.015–0.020 mm. in diameter, when its color and refractive properties distinguish

[4] JOHNSTONE, A. *On the action of pure water and of water saturated with carbonic acid gas on minerals of the mica family.* Quart. Journ. Geol. Soc. **45**: 363. 1889.

[5] GALPIN, S. L. *Studies of flint clays and their associates.* Trans. Am. Ceram. Soc. **14**: 301. 1912.

it at once. More generally, however, it is found upon close examination as very minute grains or needles which are nevertheless so clear-cut that their refractions can be plainly seen. The interference color is of the first order, but the particles are so small that the actual birefringence is thereby shown to be very high. They vary from perhaps 0.001 mm. to 0.010 mm. in diameter and if in needles are 5 or 6 times as long as they are wide. In number these grains are very abundant, but in actual bulk, they represent a very small quantity of rutile.

Rarer Minerals.—Tourmaline is well marked by its pleochromism, and its frequent occurrence is notable. Epidote is occasionally seen as a slightly greenish mineral of moderate single and double refractions. Grains of both high index and birefringence are common, though not in any abundance, and they prove to be zircon and titanite. A distinction between the two is quite possible by means of the higher interference color of the titanite. Zircon is much the commoner.

Diaspore.—This is easy to determine by its moderately high index and double refraction, and its occurrence in irregular grains. It is quite common in certain of the clays examined from Missouri. Since the diaspore in these clays or their associated rocks sometimes occurs in grains sufficiently large to be seen with the naked eye, it may be mistaken for quartz, but can be separated from it and clay by means of bromoform (sp. gr. 2.8), in which the diaspore (sp. gr. 3.4) sinks, while the associated minerals float.[6]

Texture.—It would be very difficult to standardize clays by size of particle, because any one clay is apt to be made up of particles of all sizes, and because there is no standard to use. Comparing these clays with each other, however, it may be said that relatively coarse grains average 0.100 mm. or more in size, medium grains 0.020–0.025 mm., and fine grains 0.010 mm. or less.

MINERALS IN THE BURNED CLAY

A number of the clays were molded into one-inch cubes. These were all fired for 8 hours up to 950° C. After this one

[6] WHERRY, E. T. *Field identification of diaspore.* Amer. Mineral. 3: 154. 1918.

set was refired for 8 hours to 1,150° C., and a second set for 10 hours to 1,300° C. They were then ground to thin sections and examined under the microscope.

Quartz grains usually stand out with much greater clearness in the burned than in the raw clay, due to the fact that the hydrous aluminum silicates tend to mat or fuse together to a fine-grained ground mass which holds the quartz. In some specimens a fluxing action appears to have taken place between the fine-grained material and the silica, resulting in a corrosion of the quartz, but this is comparatively rare.

Hydromica on heating to 1,150° C. either practically disappears, forming an isotropic mass, or else it loses the greater part of its interference color. The only exception to this was where the hydromica grains were much larger than usual, in which case it was noticed that the central portion of the grains retained usually the original interference color.

This change of the hydromica on heating would seem to suggest that it furnishes some of the flux for the clay, and other things being equal, there may be a connnection between the degree of densification at the temperature mentioned, and the quantity of hydromica present.

Kaolinite when not fluxed, appears to retain its shape and at least a good part of its original interference color. Tourmaline and probably epidote disappear even at 1,150° C., but the rutile, zircon, and probably titanite seem to be unaffected even at 1,300° C. The persistence of the rutile can be plainly seen even through the particles are very small.

Sillimanite was noticed in a Florida white clay fired at 1,300° C., where the conditions happened to be just right for its development. That it has formed from the large flakes of kaolinite or low-grade hydromica is clearly indicated by one composite flake of the two minerals.

The actual reason for its development is not evident, other clays carrying similar micaceous flakes, and burned at the same time, not showing the sillimanite in the burned product.

TABLE 2

FEATURES SHOWN BY THIN SECTIONS OF BURNED CLAY

							1150°C.		1300°C.
Locality	Texture	Quartz	Hydromica	Kaolinite	Rutile	Porosity Per cent	Appearance	Porosity Per cent	Appearance
Sagger clay, Hollow Rock, Tenn.	Medium	C[a]	A	A	A			9.1	Micaceous texture remains. Hydromica interference color gone. Groundmass shows mostly kaolinite interference, and very little isotropic material.
White sedimentary clay, granular, Andersonville, Ga.	Very fine		C	A	S	43.7	A fine granular aggregate, about 1/2 isotropic and 1/2 kaolinite interference color	33.1	Similar except it is beginning to develop mottled patches of low interference color.
Benton, Ky.	Medium to fine	C	A	A	A			24.5	Hydromica all gone. Quartz grains in mostly isotropic groundmass. A few low interference colors.
Enid, Miss.	Medium	C	VA	S	S			0.6	Very fine, dense, felty aggregate. Low interference. Possibly sillimanite.

[a] For explanation of letters see table 1.

TABLE 2 (*Continued*)

Holly Springs, Miss.	Fine	C	A	A	C	22.6	Hydromica gone. Quartz in fine felty groundmass, partly isotropic and partly low interference color.	13.0	Similar to preceding.
Mayfield clay, Pryorsburg, Ky.	Medium to fine	C	A	A	A	30.0	Hydromica color gone. Quartz in fine-grained groundmass, partly isotropic and partly with low interference color.	24.0	Increase in isotropic material. Rutile visible.
Kaolin, Lutesville, Mo.	Medium	C	A	A	S	14.4	Fine texture, partly isotropic, partly kaolinite interference	0.8	Little different from 1,150°
Kaolin, Saylorsburg, Pa.	Medium	C	A	A	S	21.9		0.5	Quartz in slightly felted groundmass. Some isotropic. Rutile still visible.
Washed kaolin, Saylorsburg, Pa.	Medium to fine	C	A	A	A	5.9	Fine granular aggregate. Some hydromica: Some isotropic material.	0.4	Fine granular aggregate. Hydromica gone. More isotropic material.
Crude kaolin, Saylorsburg, Pa.	Medium to fine	C	C	A	A	31.2	Granular, slightly matted groundmass. Hydromica color gone. Some isotropic material.	2.9	More isotropic material. Rutile persists.

TABLE 2 (*Continued*)

Crude kaolin, Mt. Holly Springs, Pa.	Medium	C	C	A	S	10.0	Hydromica gone. Groundmass mostly isotropic. Some kaolinite colors.	2.0	More isotropic material.
Washed kaolin, same places	Fine	C	C	VA	A	19.5	Hydromica gone. Some isotropic.	3.4	More isotropic. Rutile persists.
Kaolin, Pitt-Rowland	Coarse	A	A	A	S	51.1	Most of mica shows kaolinite interference color, except in center. Some isotropic.	30.8	Mica interference color practically all gone. More isotropic.
Kaolin, Adamson-Dickson	Medium	A		A	S	48.9	Not much different in appearance from unburned.	45.2	Not much different in appearance from unburned.
Kaolin, Beatty, Nev. Is mostly halloysite	Fine			S	S	58.2	Fine fibrous aggregate, just starting an interference color.	36.9	Same as preceding but interference color increasing.
White clay, Dry Branch, Ga.	Fine	S	C	VA	S	40.0	Fine-grained mass.	27.6	Fine-grained mass, with low interference color throughout.
White clay, Florida, washed.	Medium to fine	S	A	A	S	38.0	Fine-grained ground mass with much isotropic material, and rest small flakes of low interference.	26.1	Felty appearance, with more interference colors of low order. Some of the larger mica flakes changed to sillimanite.

This development of sillimanite by burning and its possible abundance in porcelain[7] may be the explanation of another feature noted. In some of the clays, as indicated in the descriptions, a double refraction is *produced* in the ground mass of the clay by burning to higher temperatures. It is very probable that this is caused by particles too minute to be easily recognizable, and that the development of the interference color may be due to the formation of sillimanite. The single and double refractions of the material would not be against it, but it is not proven in any way except by analogy.

In the sections where sillimanite was actually determined, it is present in the form of slender crystals of fair size, and can surely be distinguished by its moderate relief, low interference, optical character, and cross fractures.

In table 2 there are given in summarized form the features which a number of the thin sections show. They are worth recording, although the series is not sufficiently large to warrant drawing definite conclusions. For further comparison the table also gives the texture of the clay, relative abundance of the important constituents, and porosity after burning.

CRYSTALLOGRAPHY.—*An unusual sulfur crystal.* F. RUSSELL BICHOWSKY, Geophysical Laboratory. (Communicated by R. B. Sosman.)

The accidental mixing of a hot alcoholic solution of ammonium polysulfide with a mixture of benzonitrile, hydroxylamine hydrochloride, and ether resulted, among other things, in the formation of the single, well-developed, orange-red, translucent crystal figured below. The crystal was measured and figured (Fig. 1) under the impression that it was a crystal of some organic compound, but later analysis showed that it was almost pure sulfur containing 0.33 per cent carbon, 0.09 per cent hydrogen, 0.10 per cent nitrogen, 0.07 per cent ash, and a trace of chlorine. The density 2.01 is not unusual for sulfur, and the angles are in close accord with those calculated, using the Goldschmidt[1]

[7] KLEIN, A. A. *The constitution and microstructure of porcelain.* Trans. Am. Ceram. Soc. 18: 377. 1916.

[1] GOLDSCHMIDT. Krystallographische Winkeltabellen, p. 313. Berlin, 1897.

axial ratios 0.8138 : 1 : 1.9055. The crystal was about 6 mm. long and weighed 0.27 gram. The following faces were observed (both the Miller and Goldschmidt symbols are given in order): *c*, (001), 0; *b*, (010), 0 ∞ ; *a*, (100), ∞ 0; *e*, (101), 10; *m*, (110), ∞ ; *v*, (013), $0^1/_3$; *n*, (011), 01; *s*, (113), $^1/_3$; *y*, (112), $^1/_2$; *p*, (111), 1; *γ*, (331), 3; *r*, (311), 31; *ζ*, (211), 21; *q*, (131), 13; *k*, (120), ∞ 2; *h*, (130), ∞ 3; *λ*, (210), 2 ∞ ; *ρ*, (310), 3 ∞ . Of these the faces *ζ*, (211), 21, and *ρ*, (310), 3 ∞ , are new. The larger faces *m*, *p*, and *c* were all somewhat pitted and striated and often gave double signals. The other faces all gave first quality signals with the exception of faces *γ* and *ζ* which in the instruments used gave but faint (though well-defined) ones. Faces *γ* and *ζ* occurred but once, the first as a narrow imperfect bevelling of the edge (111)–(110), the second as a linelike but perfect face bevelling the edge (100)–(311). The remaining faces occurred the theoretical number of times, except faces *λ* and *ρ* which occurred three instead of four times each.

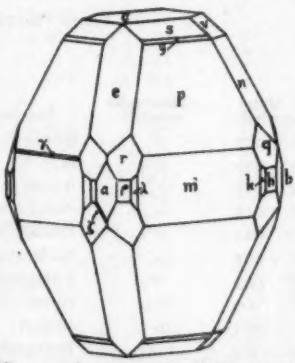

Fig. 1. An unusual sulfur crystal.

The most unusual feature of this crystal is the well-developed zone [001] containing the brachy- and macro-pinacoids *a* and *b* (2 times each), the primary prism *m* (4 times), the rare macro-prisms *k* and *h* (4 times), the rare brachy-prism *λ* (3 times)[2] and the new *ρ* face (3 times). Another interesting zone is the oblique zone [$01\bar{1}$] containing the faces *n*, *p*, *r*, *ζ*, and *a*. The corresponding zone [$10\bar{1}$] is less well developed.

The zonal relations of the crystal are in themselves sufficient to establish the symbols of the new faces, but as a check the crystal was carefully measured on a makeshift one-circle goniometer using reflections from different parts of the faces and reading on different parts of the circle. The results agreed closely with

[2] Given by GOLDSCHMIDT, loc. cit. I have been unable to find the original reference.

those calculated from the Goldschmidt axial ratio. The angles for the rarer faces are: (010)–(130), measured 22° 18′, calculated 22° 16′; (010)–(120), measured 31° 33′, calculated 31° 34′; (010)–(210), measured 67° 51′, calculated 67° 51′; (010)–(310), measured 74° 48′, calculated 74° 49′; (011)–(211), measured 65° 30′, calculated 65° 19′.

Table 1 contains a complete list of the faces reported for rhombic sulfur, their discoverer, Miller and Goldschmidt symbols, principal Goldschmidt position angles, and the number of times reported in the literature examined.

TABLE 1

FACES OBSERVED ON RHOMBIC SULFUR

$a = 0.8138$

$c = 1.9055$

Miller symbols	Goldschmidt symbols	Discoverer	Goldschmidt Angle φ	Goldschmidt Angle ρ	No. of times reported
c 001	0	Romé de l'Isle[1]		0°00′	48
b 010	0 ∞	Scacchi[2]	0°00′	90 00	28
n 011	01	Romé de l'Isle[1]	0 00	62 18′	41
v 013	$0^1/_3$	Brooke-Miller[4]	0 00	32 25′	18
w 023	$0^2/_3$	Brooke-Miller[4]	0 00	51 47′	2
θ 031	03	Molengraaf[10]	0 00	80 04′	3
ξ[c] 043	$0^4/_3$	Buttgenbach[18]	0 00[b]	72 38′	1
a 100	∞ 0	Romé de l'Isle[1]	90 00	0 00	16
e 101	10	Mohs[3]	90 00	66 52′	26
π[c] 102	$1/_{20}$	Buttgenbach[18]	90 00[b]	49 30	1
u 103	$1/_{30}$	Brooke-Miller[4]	90 00	37 58′	14
m 110	∞	Mohs[3]	50 51′	90 00	33
p 111	1	Romé de l'Isle[1]	50 51′	71 40′	72
y 112	$1/_2$	Scacchi[2]	50 51′	56 28′	23
s 113	$1/_3$	Mohs[3]	50 51′	45 10′	51
o 114	$1/_4$	Fletcher[8]	50 51′	37 02′	8
t 115	$1/_5$	Mohs[3]	50 51′	31 07′	29
ξ[c] 116	$1/_6$	Buttgenbach[18]	50 51′[b]	26 42′	2
ω 117	$1/_7$	Brezina[6]	50 51′	23 19′	9
ψ 119	$1/_9$	Zapharovich[5]	50 51′	18 32′	7
1.1.11?	$1/_{11}$	Schmidt[15]	50 51′[b]	15 21	1
1.1.14?	$1/_{14}$	Schmidt[15]	50 51′[b]	12 10	1
1.1.17?	$1/_{17}$	Schmidt[15]	50 51′[b]	10 4	1
k 120	∞ 2	Brooke-Miller[4]	31 34	90 00	3
κ 122	$1/_{21}$	Pelikan[13]	31 34	65 54′	1
h 130	∞ 3	Weed & Pirsson[12]	22 16′[b]	90 00	1
q 131	13	Brezina[6]	22 16′	80 48′	19
x 133	$1/_{31}$	Scacchi[2]	22 16′	64 06	18

TABLE 1 (*Continued*)

z	135	$^1/_5$ $^3/_5$	Brooke-Miller[4]	22 16′	51 01	16
F	151	15	Busz[14]	13 48′	84 11	1
Δ^c	155	$^1/_{61}$	Millosevich[16]	13 48′[b]	63 30	1
τ^c	201	20	Buttgenbach[18]	90 00[b]	78 13	1
λ	210	2	Goldschmidt[17]	67 51′	90 00	1
ξ^c	211	21	Bichowsky	67 51′	78 48′	1
δ	221	2	Molengraaf[10]	50 51′	80 35′	6
ν^c	227	$^2/_7$	Buttgenbach[18]	50 51′[b]	40 47	1
	229?	$^2/_9$	Buttgenbach[18]	50 51′[b]	33 51	1
φ	305	$^3/_{50}$	Millosevich[16]	90 00[b]	54 33′	1
ρ^c	310	3 ∞	Bichowsky	74 49[b]	90 00	1
r	311	31	Brezina[6]	74 49[a]	82 10′	7
α	313	$1^1/_3$	Molengraaf[10]	74 49[a]	67 36	13
β	315	$^3/_5$ $^1/_5$	Dana[9]	74 49[a]	55 30′	7
μ	319	$^3/_9$ $^1/_9$	Millosevich[16]	74 49[b]	38 58	1
γ	331	3	Friedländer[7]	50 51′	83 42	14
f	335	$^3/_5$	Busz[11]	50 51′[b]	61 06	3
g	337	$^2/_7$	Busz[11]	50 51′[b]	52 18	2
	3, 3, 16?	$^3/_{16}$	Buttgenbach[18]	50 51′[b]	29 39	1
l	344	$^3/_{61}$	Brezina[6]	42 40	68 54	1
ϵ	551	5	Busz[14]	50 51′	86 12′	2
η	553	$^5/_9$	Busz[14]	50 51′	78 35′	1

[a] Corrected value. Goldschmidt gives the erroneous value 74° 39′.

[b] New calculation.

[c] New symbol.

The symbol ′ indicates $^1/_2$′.

[1] Romé de l'Isle. Crystallogr. 1: 289. 1783.

[2] Mohs. Mineralogy, Edinburgh 3: 52. 1825.

[3] Scacchi. Mem. Geol. Campan., Rend. Ac. Nap. (1849), 103; Zts. D. Geol. Ges. 4: 168. 1852.

[4] Brooke-Miller. Mineralogy 109. 1852. (Quoted from Brezina. [6])

[5] Zapharovich. Jahrb. Geol. Reichsanst. 19: 229. 1869.

[6] Brezina. Akad. Wiss. Wien. 60: 539. 1869.

[7] Friedländer. Min. Sammlung Strassburg, 262. 1878. (Quoted from Dana, System of Mineralogy.)

[8] Fletcher. Phil. Mag. V. 9: 186. 1880.

[9] Dana. Amer. Journ. Sci. 32: 389. 1886.

[10] Molengraaf. Zeitschr. Kryst. Min. 14: 45. 1888.

[11] Busz. Zeitschr. Kryst. Min. 17: 550. 1890.

[12] Weed and Pirsson. Amer. Journ. Sci. 42: 401. 1891.

[13] Pelikan. Tscherm. Min. Petr. Mitt. 12: 344. 1891.

[14] Busz. Zeitschr. Kyrst. Min. 20: 560. 1892.

[15] Schmidt. Zeitschr. Kyrst. Min. 29: 210. 1898.

[16] Millosevich. Atti Accad. Lincei 7: 2 Sem.: 249. 1898.

[17] Goldschmidt: Quoted in Krystallographische Winkeltabellen, Berlin, 313. 1897.

[18] Buttgenbach. Ann. Soc. Geol. Belg. Liege (1898), 25 Mem. 73.

Figure 2 is a stereographic projection of the known faces. The dots representing the known faces have an area proportional to number of times reported. This figure emphasizes the more important zonal relations of sulfur and particularly the predominance of the primary pyramid zone [1$\bar{1}$0]. The brachy- and macro-dome zones [$\bar{1}$00] and [$\bar{0}$10], as well as the oblique zones [101] and [011], are also well developed. Among the lesser zones sulfur shows a curious preference for zones (and faces)

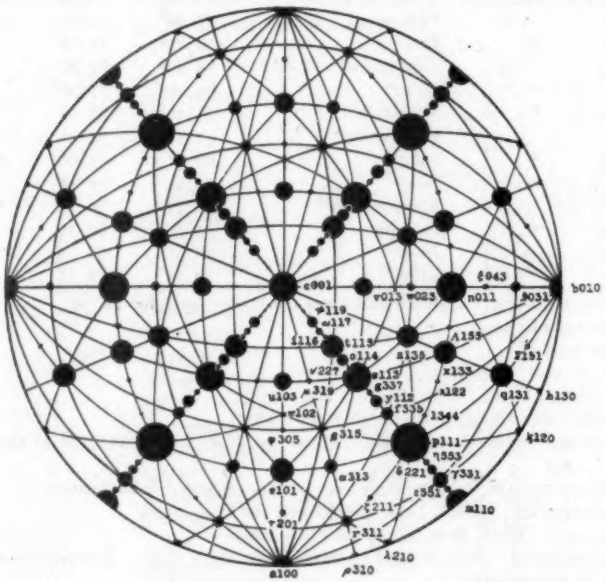

Fig. 2. Stereographic projection of the known faces of sulfur crystal.

with an intercept ratio involving an odd number such as 3, as compared with those involving an even number such as 2. Compare the development of the zones [$\bar{1}$30], [3$\bar{1}$0], [$\bar{1}$03], [30$\bar{1}$], [03$\bar{1}$], [0$\bar{1}$3], with the corresponding zones [$\bar{1}$20], etc. The poor development of zones, except [110], having (110) as a pole is interesting. The usual rule that faces at the intersection of important zones are likely to be most commonly developed is

well emphasized in sulfur, as are certain quantitative relations, but the number of sulfur crystals reported is too small to make quantitative relations of much value.

MINERALOGY.—*Plancheite and shattuckite, copper silicates, are not the same mineral.* WALDEMAR T. SCHALLER, Geological Survey.

The name plancheite was given by Lacroix,[1] in 1908, to a blue copper silicate from the French Congo, Africa. About five years later a blue copper mineral from Bisbee, Arizona, sent to the U. S. Geological Survey for identification, by Philip D. Wilson, of Bisbee, was determined by qualitative tests as probably plancheite. Abundant material was available for various determinations and it was soon found that several discrepancies existed between the properties of the two minerals from Arizona and from Africa. Accordingly a detailed investigation of the Arizona material was undertaken and it was determined that the Arizona mineral was not plancheite and that an additional new copper mineral was intimately associated with and genetically derived from the more abundant blue mineral, which in a preliminary note[2] was named shattuckite, the other new copper mineral being called bisbeeite. So far as known to the writer, plancheite has not been found in Arizona. The essential properties of shattuckite and of bisbeeite were published in the Third Appendix to Dana's System of Mineralogy. The paper describing in detail the properties of these two new copper silicates has not yet been published.

Zambonini[3] has recently questioned the validity of shattuckite as a separate species and has urged its identity with plancheite. He gives a new analysis of plancheite which does not agree with

[1] LACROIX, A. *Sur une nouvelle èspece minéral, provenant du Congo français.* Compt. Rend. 146: 722–725. 1908; *Les minéraux accompagnant la dioptase de Mindouli (Congo français): plancheite, nov. sp.* Soc. Franç. Minéral. Bull. 31: 247–259. 1908.

[2] SCHALLER, W. T. *Four new minerals.* Journ. Wash. Acad. Sci. 5: 7. 1915.

[3] ZAMBONINI, F. *Sur l'identité de la shattuckite et de la plancheite.* Compt. Rend. 166: 495–497. 1918.

the original one, but which does agree with the analyses of shattuckite. Explanations of his results are suggested at the close of this paper.

The nonidentity of shattuckite with plancheite, notwithstanding their very close resemblance in properties and in chemical composition, was definitely determined before the name shattuckite was proposed. The direct comparison of the two minerals was readily made, as Prof. Lacroix had kindly presented to the writer in Paris in 1912 a typical specimen of plancheite. The available specimen could not yield a sample of plancheite of the requisite purity for chemical analysis. Plancheite is intimately mixed with other copper silicates, the most abundant of which in the single specimen examined, is what is ordinarily called chrysocolla. A set of three thin sections of parts of the plancheite specimen shows that probably several other copper silicates are also present, although the two named are predominant. The fibers and spherulites of plancheite are imbedded, in places, in the massive pale green chrysocolla and the other copper silicates. The thin sections also show that although small fairly pure masses of plancheite spherulites occur in the rock, these masses are bordered by a layer of some other copper mineral. Judging only from the single specimen, it would be most difficult, if not impossible, to prepare even a very small sample of nearly pure plancheite for chemical analysis.

Abundant shattuckite was available, from which samples were prepared that after careful selection contained only small amounts of included tenorite. The analyses of three different samples of shattuckite establish its formula as $2CuO.2SiO_2.H_2O$; whereas the formula of plancheite, as revised, is given as $6CuO.5SiO_2.2H_2O$ (the original formula proposed is $15CuO.12SiO_2.5H_2O$).

If the only quantitative basis for determining the question of the supposed identity of shattuckite with plancheite were the chemical analyses, then the two minerals would readily be considered as identical. But there is a simple and absolutely conclusive method by which the question as to the identity of the two minerals can be answered. This is by a comparison of their

optical constants, of which the refractive indices are the easiest determined. If the refractive indices show a distinct difference, then the minerals are not the same.

The refractive indices of both minerals were determined by the writer before any mention of shattuckite was published and it was found that the lowest refractive index (α) of shattuckite was considerably higher than the highest (γ) refractive index of plancheite. The actual determinations are shown in table 1; there are also given the independent determinations kindly made by E. S. Larsen, of the U. S. Geological Survey. Mr. Larsen's values are more accurate than those of the writer and should be taken as the correct values. The accurate determinations of the refractive indices of such finely fibrous minerals as those under discussion is an operation requiring very careful work and considerable experience.

As table 1 readily shows, there is sufficient difference in the optical constants of shattuckite and plancheite to preclude their being identical.

TABLE 1

REFRACTIVE INDICES OF PLANCHEITE AND SHATTUCKITE

Index	Plancheite				Shattuckite	
	Lacroix [a]	Larsen [b]		Schaller	Larsen	Schaller
α	n.d.	1.645	1.640	1.644	1.752	1.730
β	n.d.	1.660	n.d.	n.d.	1.782	n.d.
γ	1.70	1.715	1.697	1.702	1.815	1.796

[a] Stated to be near 1.70 (γ), LACROIX, A. Minéral. France 4: 758. 1910.
[b] Two sets of determinations, made at different times.

Zambonini's analysis of plancheite yields the same formula as has been derived for shattuckite and he naturally concludes that the two minerals are the same. Two suggestions are offered: (1) that, through inadvertence, the mineral furnished Zambonini (obtained from Lacroix in Paris) really was shattuckite and not plancheite. This suggestion could have been readily proved or disproved by a determination of the refractive indices of the

material analyzed; (2) the material analyzed (plancheite) contained enough impurities (copper silicates) to affect the composition of the sample so that the results obtained are comparable to the composition of shattuckite.

But whatever may be the exact chemical relations of these two minerals and whatever may be the formula of plancheite the difference in the refractive indices proves conclusively that they are not the same.

PALEONTOLOGY.—*Description of a supposed new fossil species of maize from Peru.* F. H. KNOWLTON, U. S. National Museum.

Some months ago the United States National Museum came into the possession of a very remarkable specimen of fossil corn from Peru. It was sent in as an ethnological specimen, having been secured from a dealer in curios in the city of Cuzco, Peru, by Dr. W. F. Parks, of St. Louis, Missouri. Dr. Walter Hough, of the Division of Ethnology in the National Museum, brought the specimen to me for identification. Although it is wonderfully well preserved, it is in many particulars so different from the ordinary types of corn with which I was familiar that its affinity was not recognized until this was pointed out by Mr. G. N. Collins, of the U. S. Department of Agriculture, who for many years has been making a special study of the origin, evolutionary history, and distribution of Indian corn (Zea).

Fig. 1. Fossilized ear of corn.

The specimen has suffered practically no distortion during fossilization, though a portion of the apex has been broken off and lost. It is now a little more than 6 centimeters in length and was probably about 8 centimeters long when complete. The greatest diameter is nearly 4 centimeters. The point of attachment for the "ear" was very small, suggesting that it

was perhaps drooping, unless it was held upright by the developing leaves. The axis or "cob" has entirely disappeared so far as any structural elements are concerned, and its place has been filled by a closely cemented, fine-grained siliceous sand. The individual kernels or grains of corn are mostly roughly triangular in shape, and markedly different in size. The grains are not arranged in vertical rows but in some parts of the ear there is evidence of their being in diagonal rows, though this is perhaps accidental. When viewed as a whole the grains appear to be very irregularly placed. In color the grains are dark brown, almost black, and as the matrix replacing the axis is light yellow in color, the grains stand out in strong relief. No structural or cellular elements are retained in the interior of the grains, this being filled with very fine-grained compact sand.

Now the question arises as to the name by which this unique specimen should be known. It must be confessed at once that it proves exceedingly difficult, if not, indeed, impossible, to find characters by which it can be adequately separated from certain living types, such, for instance, as the Copacabana variety from the regions of Lake Titicaca, yet the fact that it is so completely fossilized lends support to the probability of its being several thousand years old instead of a few hundred years. For this reason alone, and in order that it may be independently referred to, I venture to give it the name *Zea antiqua*.

It is of course extremely unfortunate that nothing is known as to the condition under which this specimen was found. If this were known it might be possible to fix its age with a reasonable degree of certainty. As it stands, however, there is little but the fact of its thorough fossilization to base an opinion on, and from this I venture the tentative suggestion that it seems hardly likely to be younger than at least several thousand years. In a recent paper on "The evolution of maize," by Paul Weatherwax,[1] he says: "Geology and archaeology are of little value to us in solving these problems, since the oldest remains of these plants found in the rocks or in human habitations are practically modern."

[1] Bull. Torrey Club **45**: 334. 1918.

It seems to me that the specimen under discussion falls very little short of supplying the needed paleontological data on the antiquity of maize. Its very modern appearance may of course readily be interpreted as an indication of its comparatively recent age, but, on the other hand, there is more than a reasonable conjecture that it could be actually as old as has been suggested, in which case it shows that the real ancestors of maize must apparently be sought much earlier than has usually been assumed.

ZOOLOGY.—*The systematic position of the crinoid genus Holopus.* AUSTIN H. CLARK. U. S. National Museum.

The systematic position of *Holopus* has never been definitely determined. In the latest general work on the Crinoidea[1] it was placed by Springer and Clark at the end of the Articulata, in Family 8, Holopidae, beyond Family 7, Eugeniacrinidae, and Family 6, Saccocomidae; but this disposition was admittedly provisional.

Holopus has frequently been associated with *Edriocrinus*, but it does not seem possible that the two can really be closely related.

In *Holopus* the disc, arms, and pinnules are so obviously of the same type as those of the pentacrinites and comatulids that the relationship with these forms can scarcely be denied. The arms of *Holopus* are very short and thick and closely appressed against each other; comparison, therefore, must be with the closely appressed arm bases of such types as *Endoxocrinus* or the genera of the Charitometridae (especially *Crinometra*) and not with the distal portions of the pentacrinite or comatulid arms, or with the widely separated arms of many forms. The asymmetry of *Holopus* is duplicated in many of the Comasteridae.

The disc of *Holopus* is identical in character with that of the very young of the comatulids in which perisomic plates are present—*Comactinia*, *Comissia*, *Thaumatocrinus*, and *Pentame-*

[1] Zittel-Eastman's "Paleontology," 1913, p. 241.

trocrinus—even to the detail of the slight eversion of the edges of the orals.

So far as I can see, the column of *Holopus* is composed of radials only. In the young specimen figured by Alexander Agassiz the uniformity of the ornamentation on the outer ring appears to indicate that it is composed of a single series of plates, which must be the radials. In one of the specimens figured by P. H. Carpenter[2] the series of tubercles running down the median line of each sector of the column indicates that the same plate (the radial) persists as far as this ornamentation extends, and probably also to the circumference of the basal disc.

An analysis of all the available characters[3] indicates that *Holopus* occupies practically the same developmental plane as the pentacrinites and the comatulids; indeed it is questionable which of the three groups should be considered the most specialized.

My personal opinion is that the pentacrinites, the comatulids, and *Holopus* are very closely related, in spite of their extraordinary superficial dissimilarity.

In the pentacrinites the column is enormously developed; so rapid is the growth that the proximales as they are continuously formed beneath the calyx never succeed in becoming attached to it, but are continuously pushed outward by the formation of new proximales between the last formed and the calyx; the proximales later become separated by the intercalation of other columnals, appearing in the fully developed column as the cirriferous nodals. The basals are much reduced and lie horizontally.

In the comatulids a short column is formed and a proximale appears which, becoming firmly attached to the calyx, increases enormously in size and, the larval column being discarded, contains the entire adult stem. The basals, in nearly all the types, become metamorphosed into an internal septum and entirely lose their original character. The base therefore is entirely com-

[2] *"Challenger" Report, Stalked Crinoids*, 1884, plate III, fig. 1.

[3] *Phylogenetic study of the recent crinoids*....., Smiths. Misc. Coll. 65: No. 10. August 19, 1915.

posed of radials, practically horizontal in position, plus the proximale.

In *Holopus* the same line of specialization has apparently been followed further; the column and the basals have disappeared, and the attachment is by means of the radials, which in the comatulids dominated the base. It is conceivable that the very young *Holopus* is essentially like a short-stemmed comatulid in which the radials, growing very rapidly, form a cylindrical ring with the basals, spread outward until they all lie in the same plane, closing the proximal end, and that this ring becomes attached by its lower border to the object upon which the larva rests.

ANTHROPOLOGY.—*A second archeological note.*[1] TRUMAN MICHELSON, Bureau of American Ethnology.

Nearly three years ago I showed in this JOURNAL[2] that the provenience of the gray sandstone pipe discussed by Squier and Davis in their *Ancient monuments of the Mississippi Valley*, pages 249 and 250, must be the upper Mississippi region near the Rock River because the original of the pipe figured there is either the same as that of the Sauk pipe shown on plate 2 at the end of volume 2 of Beltrami's *Pilgrimage*, or it belongs to the same culture. It will be recalled that previously there was uncertainty as to the provenience of this pipe. I now find that the lowest of the three pipes shown on the plate facing page 279 of Em. Domenech's *Voyage pittoresque*, said to be from Tennessee, is also of the same culture; indeed it is almost impossible not to believe that the same artist fashioned all three pipes, so great is their likeness.

[1] Published with the permission of the Secretary of the Smithsonian Institution.
[2] 6: 146. 1916.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. The abstracts should conform in length and general style to those appearing in this issue.

INORGANIC CHEMISTRY.—*Note on the sintering of magnesia.* JOHN B. FERGUSON. Journ. Amer. Ceram. Soc. **1**: 439–440. June, 1918.

The sintering of chemically pure magnesia has been generally regarded as difficult if not impossible, and this note is intended to place upon record the conditions under which such a sintering was found to take place readily. Pure magnesia powder, upon prolonged heating at temperatures ranging from 1600° to 1720° C., sinters to a cake of considerable mechanical strength and this sintering is due to a recrystallization, forming a mass of interwoven crystals, rather than to the presence of any bonding materials. J. B. F.

ENTOMOLOGY.—*Origin of the castes of the common termite,* Leucotermes flavipes *Kol.* C. B. THOMPSON. Journ. Morph. **30**: No. 1. 1917.

Termites, since they belong to that most interesting group known as "social insects," have been studied with interest by entomologists for many years. One of the most important unsolved problems in the complex life cycle of termites has been the origin of the castes.

There have been two theories as to the origin of the castes. According to most of the older writers, all the young are undifferentiated or alike upon hatching, and only become differentiated later through the external influences of food or protozoan parasites; the other view is that the castes are predetermined in the egg or embryo by intrinsic factors.

Dr. Thompson shows that the fertile and sterile types are predetermined at the time of hatching and may be distinguished by the bulk of the brain, the relative size of brain and head, the structure of the compound eyes, and the size of the sex organs. He also proposes a simplification in the nomenclature of forms and castes in termites and in this and a previous paper on the origin of the frontal gland in termites. T. E. SNYDER.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY OF WASHINGTON

The 809th meeting of the Society was held at the Administration Building of the Carnegie Institution, November 23, 1918; Vice-President HUMPHREYS in the chair; 50 persons present.

Mr. W. F. MEGGERS presented the first paper on *Photography of the red and infra-red solar spectrum*. This paper was illustrated by lantern slides.

Ordinary photographic plates stained with dicyanin have been used extensively for several years at the Bureau of Standards in recording the arc spectra of metals and tube spectra of gases in the red and adjacent infra-red spectral regions. The spectra of about half of the chemical elements have thus been investigated from the yellow at wave-lengths of about 6000 A into the infra-red to about 9000 A, and in some cases to wave-lengths greater than 10,000 A.

This success in photographing the long waves from artificial sources suggested an attempt to photograph the infra-red solar spectrum on dicyanin stained plates, for, up to the present time, no complete or accurate determinations of wave-lengths corresponding to Fraunhofer lines in the infra-red have existed, and there have been scarcely any reliable measurements in spectra of the chemical elements in this same region; identifications of absorption and emission lines have, therefore, been few and uncertain.

This work was first undertaken at the Johns Hopkins University in April, 1917, and a brief account of it was published in the Astrophysical Journal[1] together with a map of the solar spectrum from 6860 A to 9600 A. Over 2000 Fraunhofer lines were measured between wave-lengths limits and about 400 of them were identified with emission

[1] MEGGERS. Astrophys. Journ. 47: 1. 1918.

lines in the spectra of twenty of the chemical elements. Nearly 80 per cent of the total number of lines remained unidentified, and many of these, in addition to the well-known absorption bands A and B, due to oxygen in the earth's atmosphere, were suspected to be of terrestrial origin. An opportunity to separate the solar from the telluric lines by aid of the Doppler-Fizeau displacement suffered by lines of solar origin came with an invitation to use the Porter spectrograph at Allegheny Observatory. Light from the eastern and western limbs of the sun was photographed simultaneously in two parallel spectra in which all lines of solar origin appear displaced in opposite directions, while those due to absorption in the earth's atmosphere have the same wave-lengths in both spectra. The spectrograms show that about 75 per cent of the absorption lines with wave-lengths between 6400 A and 9400 A arise in the atmosphere of our earth.

A line (wave-length 7664 A) characteristic of potassium is under ordinary circumstances exactly coincident with one of the lines in the A band due to terrestrial oxygen, but was compelled to betray its solar origin by means of the Doppler-Fizeau effect. The presence of free oxygen in the solar atmosphere was demonstrated by the coincidence of six solar lines with lines in the emission spectrum of oxygen. All of the evidence for solar oxygen lies in its infra-red spectrum.

Discussion: This paper was discussed by Messrs. SOSMAN and HUMPHREYS.

The second paper on *The hot spell of August, 1918*, was presented by Mr. A. J. HENRY.

The hot spell of the first decade of August, 1918, had its origin over Montana and the central and northern Plains States. It was practically stationary over eastern Kansas and western Montana from the 1st to the 3d, inclusive, and on the 4th spread eastward by way of the Ohio valley to western Pennsylvania and also northeastward into the southern part of the Lake region. On the 5th it reached its greatest geographical extension; the area affected on the evening of that date was a little more than a million square miles, or just about one-third of the area of the United States, excluding Alaska and outlying possessions. The increase in the area of the heated territory from the 4th to the 5th was in round numbers a quarter of a million square miles. The peak of the high temperature in the west was reached on August 3–5 and in the east on August 6–7. In the east the daily maxima declined irregularly until the 14th, when normal conditions were reached. The period of extraordinarily high temperature was short, not exceeding three days at any one place. The high temperatures were associated with a dry atmosphere and there was therefore not much bodily discomfort and but few heat prostrations were reported in the daily press.

The abnormally high temperature was due to a combination of favorable circumstances. These in the order of their importance are: (1) A pressure distribution that inaugurated and maintained a system of southerly winds over the great interior valleys and the middle Atlantic

States. (2) The prolonged period of high temperature over the Plains States preceding the hot spell. (3) The absence of clouds and consequently unhindered insolation throughout the period of the hot weather.

Diagrams were shown illustrating the pressure distribution in the United States at the beginning of the hot spell and its daily eastward advance to the Atlantic.

The eastern limit of the hot weather corresponded roughly with the 72d meridian of west longitude, which it may be remembered passes through central Massachusetts.

Local thunder showers set in over the upper Ohio valley, the northern portion of the Appalachian region, western Maryland, and the District of Columbia in the later afternoon of the 7th, bringing to an end in those districts the unusually high temperatures that had prevailed during the preceding 48 hours. While high maxima were recorded in eastern Pennsylvania, eastern New York, and western New England on the 7th, local showers on the 8th brought relief from the extremely high maxima but normal temperatures were not reached in the east until the 14th.

Discussion: This paper was discussed by Messrs. WHITE, KIMBALL, HUMPHREYS, KADEL, and HAYFORD.

The 810th meeting, being the 48th annual meeting of the Society, was held at the Administration Building, Carnegie Institution, December 7, 1918; President Burgess in the chair; 22 members present.

The report of the Secretaries was read by Mr. E. C. CRITTENDEN. This report showed that the present active membership is 182, a net gain of 12 during the past year. Among the active members there were seven deaths during the year, namely: HENRY ADAMS, THOS. B. FORD, G. K. GILBERT, R. A. HARRIS, ARTEMAS MARTIN, RICHARD RATHBUN, GEO. M. SEARLE. Also one member on the absent list, Captain ERNEST WEIBEL, died of wounds received in France. There was one resignation during the year and thirteen were transferred to the absent list, a number of these being men who were engaged in overseas military duty. There were 33 new members elected during the year.

The Society held 14 meetings for the presentation of papers. At these meetings 33 communications were presented. About 15 per cent of the Society presented papers. The average attendance at the meetings was 45, constituting about 25 per cent of the membership of the Society.

The General Committee adopted new By-laws on December 22, 1917, to supplement the revised By-laws of the Society which had been adopted November 24, 1917. These By-laws have been published and issued to the members of the Society.

The report of the Secretaries was accepted and ordered placed on file.

The report of the Treasurer was read by Mr. E. F. MUELLER. This report shows that the receipts from dues, interests on investments, and miscellaneous items amounted to $1,194.96. The expenses for the same period, including expenses of the officers, programs, hall for meetings, and grants, amounted to $804.34. In addition, the Cosmos Club bond of $1,000 was paid and a Chicago, St. Paul and Minneapolis Railway bond was purchased for $1,065.50. The balance on hand December 6, 1918, is $509.25, being $325.12 greater than the balance on hand one year previous. The par value of the securities held by the Society is now $12,500, being the same as one year previous. A list of the securities held by the Society is attached to the Treasurer's report, as is also a list of delinquent dues and the estimated liabilities of the Society. The excess of income over expenditures for 1918 is shown to be $377.38.

The Auditing Committee reported that it examined the books of the Treasurer and found the Treasurer's report to be a correct statement of the resources and liabilities of the Society.

The reports of the Auditing Committee and Treasurer were ordered accepted and placed on file.

The report of the Tellers, consisting of Messrs. D. R. HARPER and R. M. WILHELM, was read by Mr. HARPER. A total of 42 ballots was received. Following the report of the Tellers, the Society proceeded to the election of a President, two Vice-Presidents, Recording Secretary, and two members of the General Committee. The result of election is as follows: *President*, W. J. HUMPHREYS; *Senior Vice-President*, R. B. SOSMAN; *Junior Vice-President*, R. L. FARIS; *Recording Secretary*, S. J. MAUCHLY; *Treasurer*, E. F. MUELLER; *General Committee*, H. H. KIMBALL, F. E. FOWLE, and D. L. HAZARD, to fill unexpired term of Mr. SWANN.

H. L. CURTIS, *Recording Secretary.*

The 811th meeting was held at the Administration Building of the Carnegie Institution, January 4, 1919; President HUMPHREYS in the chair; 72 persons present.

The evening was devoted to hearing the address of the retiring President, Mr. GEORGE K. BURGESS, on *Science and the after-war period.* The address was published in this JOURNAL.[1]

S. J. MAUCHLY, *Recording Secretary.*

BOTANICAL SOCIETY OF WASHINGTON

The 130th regular meeting of the Society was held at the Cosmos Club at 8 p.m., Tuesday, October 1, 1918. Thirty-two members and three guests were present. The following paper was presented:

The eradication of the citrus canker: KARL F. KELLERMAN. Since the autumn of 1914 the Bureau of Plant Industry of the U. S. Department of Agriculture has been cooperating with the Gulf States in a

[1] 9: 57–70. 1919.

campaign for the eradication of the canker disease of citrus fruit and trees. The first observation regarding a plant disease which presumably was citrus canker is with reference to nursery stock introduced into Texas in 1911. It is not improbable that earlier shipments of nursery stock were infected, and it is certain that many later shipments of *Citrus trifoliata* orange seedlings from Japan, both into Texas and into other Gulf States, were infected.

Citrus canker is primarily a leaf-spot and fruit-spot, although it also affects twigs and even old bark and wood. In its early stages, however, it resembles the sour-scab of citrus trees, a troublesome but not an especially serious disease that is widely prevalent in the South. Until late in the year 1913 plant pathologists and nurserymen did not clearly distinguish between these two diseases, and, therefore, prior to its recognition and the determination of its serious character, the shipment of infected nursery stock was probably taking place throughout the southern areas where citrus culture was being extended.

During the seasons of 1913 and 1914 special efforts were made by State nursery inspectors, by nurserymen, and by citrus growers to check the spread of the disease by complete defoliation of infected stock followed by immediate and thorough spraying with strong Bordeaux mixture and by painting visible infections with Bordeaux paste. These treatments were ineffectual, however, and citrus growers in southeastern Florida became so concerned over the rapid and destructive spread of citrus canker and the failure of the methods usually employed for controlling plant diseases that they originated the plan of spraying infected trees with burning oil, thus completely destroying them. Eradication work of this character was undertaken immediately and financed almost entirely by private subscriptions, but the disease appeared to be gaining upon the forces attempting to control it.

Severe tropical storms, in addition to the usual means of spreading the contagion, considerably increased the number of properties infected. The grapefruit, the orange, the lime, and the lemon are so readily infected with citrus canker that it does not appear probable that any method except that of complete destruction of all infected trees will serve to check the disease in any locality. Even at the worst, however, but a very small fraction of the citrus properties of the South have been infected, and those in California have escaped completely. Furthermore, the infected properties usually can be cleansed of the disease before many trees are lost.

Throughout the last three years great emphasis has been given to the necessity of unusual precautions and constant care to prevent the spread of canker, which is extremely infectious to all kinds of citrus trees. The progress of the work has been very satisfactory, and there appears to be no doubt that the few infections occurring in South Carolina and Georgia have been eradicated, so that further work in these states will not be necessary. The amount of infection in Florida, Alabama, Mississippi, Louisiana, and Texas has been very greatly reduced, and while very thorough scouting and inspection will be neces-

sary in these States, in order promptly to locate scattered infections which may occur, it is believed that further seriously destructive outbreaks of canker can be prevented.

The 18th annual meeting of the Society was held immediately after the regular meeting. In the absence of the regular officers, all reports were omitted. The following officers were elected for the ensuing year: *President*, KARL F. KELLERMAN; *Vice-President*, C. R. BALL; *Recording Secretary*, CHAS. E. CHAMBLISS; *Corresponding Secretary*, R. K. BEATTIE; *Treasurer*, L. L. HARTER. WALTER T. SWINGLE was nominated for *Vice-President* in the Washington Academy of Sciences.

The 131st regular meeting of the Society was held in the Assembly Hall of the Carnegie Institution at 8 p.m., Thursday, December 5, 1918.[1] Forty-four members and three guests were present. The following papers were presented:

Effect of temperature and other meteorological factors on the growth of sorghums: H. N. VINALL. The speaker stated that the purpose of this study was to determine the reactions of the sorghum plant to climatic conditions. Several varieties were grown under field conditions at Chillicothe, Texas, Bard and Chula Vista, California, and Puyallup, Washington. The average of the monthly means of temperature for the growing seasons at the above points was 75.6°, 81.8°, 62.4°, and 60.4° F., respectively. The percentage of actual to possible sunshine was 75, 93, 68, and 46. The total degrees of positive temperature received by the sorghums at Chillicothe was 3028°, at Bard 4236°, at Chula Vista 1895°, and at Puyallup 1615° F.

None of the sorghums matured at Puyallup, but all matured at Chula Vista with only 280° difference in the total of positive temperatures. This would seem to indicate that the amount of sunshine is an important factor in bringing sorghums to maturity. The conformance of the sorghums of Chillicothe, Bard, and Chula Vista to Linsser's Law of Growth was remarkable. The "physiological constant," according to this law, for the period from planting to maturity, was for Chillicothe 0.539, Bard 0.530, and Chula Vista 0.526.

Vegetative characters which are ordinarily considered stable, such as the number of leaves per plant, varied with the climatic conditions. Blackhull kafir had 3 and Sumac sorgo 6 more leaves at Bard than at Chula Vista. The varieties also showed decided differences in height and diameter of the stem and in the size of the leaf at these two places.

Studies on the effects of different dates of planting at Bard indicate that "more favorable conditions are obtained if the date of planting is regulated so that the early stages of the plant's development coincide with a period of high temperatures and the later stages, when the plant is nearing maturity, come when moderate temperatures prevail."

[1] The November meeting was not held on account of the influenza epidemic.

Defects in wood in relation to airplane construction: Lieut. J. S. Boyce. Since airplane construction aims to secure the maximum strength with the minimum weight, it is self-evident that wood with any defects which weaken it appreciably must not be used for this purpose.

One type of defect is the so-called advance rot, which is merely the early stages of decay, the fungus mycelium having already invaded and weakened the wood, but the only microscopical evidence of this condition is a slight discoloration of the wood. Advance rot is quite prevalent in the more important woods used in airplane construction, among which are Sitka spruce (*Picea sitchensis*), Douglas fir (*Pseudotsuga taxifolia*), yellow birch (*Betula lutea*), white oak (*Quercus alba*), and white ash (*Fraxinus americana*). Considerable skill is necessary to separate stock with advance rot from that with harmless discolorations resulting from chromogenic fungi or other causes.

Very slight lightning wounds, known as "lightning rings," are serious defects in airplane members, since there is a decided tendency for the wood to separate easily along the annual rings in which such wounds occur.

In order to make such defects properly understood in their relative importance, it will be necessary to disseminate information in simple form concerning the structure, mechanical properties, and defects of wood throughout the airplane industry.

The 132nd regular meeting of the Society was held in the Assembly Hall of the Carnegie Institution at 8 p.m., Wednesday, January 15, 1919. Thirty members and five guests were present. Mr. Clifford H. Farr, of the Bureau of Plant Industry, was elected to membership. The following papers were presented:

The potash-containing marls of the eastern United States: R. H. True. Greensand marls were first recognized in America in 1768 near Marlboro, New Jersey. After the Revolution their use as fertilizers developed rapidly, marl railroads having been built in the early thirties to haul marl from the most valuable deposits to the surrounding farming country. In the early forties over a million tons were shipped by rail in one year in this state alone. The digging of similar deposits discovered in Virginia began about 1833 and ceased only when the Civil War broke out. The war and the heavy demand on labor led to the ready adoption of guano, ground bone, and other concentrated fertilizers, and marling practically ceased.

In 1824 Seybert found them to contain calcium carbonate, potassium, and other substances. Rogers and others claimed chief value for potassium, Ruffin for the lime. With the present shortage of potassium these marls furnish a useful source for a very great supply over a practicable hauling radius. Marl samples collected in New Jersey and in Virginia when used in sand cultures yield sufficient available potassium to support a normal growth when supplied at the rate of five or more tons per acre.

Germination of immature seeds: J. B. S. Norton. The consideration of immature seed harvested under certain conditions in the case of

some crops and at all times with other crops leads to a number of practical questions. It was shown in the experiments reported that wheat seed first began to germinate six days after blossom. Germination increased to 78 per cent at the end of two weeks, then decreased at ripening time and rose slowly to 92 per cent a month after harvest. Corn began to germinate when 12 days old, germinated over 20 per cent in the roasting-ear stage, 88 per cent at four-weeks age, then declined and rose slowly after the grain began to lose weight. Tomatoes, peas, and cowpeas germinated well before maturity, and a number of other species germinated to some extent. Blackberry, lily, euphorbia, and ragweed, seeds that might be expected to have difficult germination when ripe, were tried in immature condition to see if the cause of dormancy acted before ripening. No germination was obtained in these species.

The 133rd regular meeting of the Society was held at the Cosmos Club at 8 p.m., Tuesday, February 4, 1919. Fifty-eight members and five guests were present. Messrs. M. N. POPE, CURTIS H. KYLE, J. P. BENSON, J. I. LAURITZEN, R. N. JONES, P. G. RUSSELL, L. G. HOOVER, and J. A. STEVENSON were elected to membership. The program consisted of the following papers:

Producing self-fertile muscadine grapes (with lantern): CHAS. T. DEARING. The office of Horticultural and Pomological Investigations of the U. S. Department of Agriculture has conducted muscadine-grape investigations for the past 12 years with a view to the development of this native type of grape as a fruit industry for the southeastern United States where other grapes do not thrive. These investigations have been in the nature of field surveys, studies of proper cultural, handling, and utilization methods, and breeding.

The breeding work has aimed toward maintaining the desirable characters of the species while securing improvement in those ways in which this seemed possible. The production of self-fertile varieties has undoubtedly been the most important result. At the time these investigations were undertaken, there was not such a thing as a self-fertile muscadine grape. All the fruiting varieties were self-sterile and dependent on insects to bring fertile pollen from the wild male muscadines. The Department now has a large collection of self-fertile varieties.

The value of these self-fertile varieties is evident. (1) They are of inestimably great value in breeding work in that they afford for the first time the opportunity to intercross within the species without using as one parent a variety of unknown fruiting qualities (male vine). Breeding directly for a combination of the desirable characters found in the fruiting varieties of *V. rotundifolia* is now possible. (2) They afford directly a cluster of increased size (a breeding object) in that the self-fertile varieties are the result of perfecting the large-clustered male-type blossoms rather than the small-clustered female-type blossoms. (3) They afford greater productiveness in that they are able to set a larger per cent of the bloom buds as berries due to their self-fertility.

They afford opportunities for greater vineyard production as well as vine production, for they can be used in place of nonproductive male vines as pollinators for imperfect hermaphrodites.

It has been abundantly proved that the new perfect-flowered or hermaphroditic type is a result of perfecting the pistils of the bloom of the male type of vine rather than the rudimentary stamens of the bloom of the female type. It is believed that it is merely a matter of time until only perfect-flowered, self-fertile muscadine grapes will be grown in the vineyards of the South.

Plant responses under artificial light (with lantern): L. C. CORBETT. That light is one of the most important factors in the environment of green plants has been recognized as long as any phenomenon of plant physiology has been observed. Many experiments have been conducted to demonstrate the effects of the presence or absence of light as a factor of environment. The great majority of these experiments are merely qualitative. They demonstrate the effect of a force with no attempt to analyze or measure it. Plant physiology has up to recent time been largely a qualitative science. This is to be explained chiefly on the ground that bio-chemistry has not been sufficiently developed to permit plant physiology to be other than a qualitative science. While, as has been stated, there are numerous simple tests to illustrate the fact that light directly influences various plant activities, few studies have been undertaken to show the relation of various portions of the spectrum to plant responses.

More than twenty years ago the speaker had an opportunity to conduct a series of tests to determine the influence which artificial light, used as a supplement to daylight, might have on the rate of development of various plants growing in greenhouses. After a series of tests extending over three years to determine the influence of incandescent gas light as a supplement to daylight, a series of tests was inaugurated to determine the influence of various-colored incandescent gas lights on plant growth, when used as a supplement to daylight. In these tests incandescent gas lamps were provided with globes tinted red, blue, and green. The behavior of plants in the field of such lights was compared with the behavior of like plants in the field of lamps carrying clear globes. Different plants gave varying responses under the stimulus of the different-colored light, but each light induced a characteristic effect which was consistent for all plants, but in varying degrees.

CHAS. E. CHAMBLISS, *Recording Secretary.*

ENTOMOLOGICAL SOCIETY OF WASHINGTON

The 319th regular meeting of the Society was held Feb. 6, 1919, in the new Assembly Hall of the Cosmos Club; 36 members and 10 visitors were present.

The following new members were elected: Dr. U. C. LOFTIN, of the Bureau of Entomology, JOHN D. SHERMAN, of New York, and E. A.

McMAHON, of the Entomological Laboratory at Annapolis Royal, Nova Scotia.

The regular program was as follows:

W. M. MANN: *Notes on the Solomon Islands.* An account of a collecting trip to these islands, illustrated by lantern slides showing the topography, flora, fauna, and the various types of natives, their dress, habits, implements, and customs.

N. E. McINDOO: *The olfactory sense of lepidopterous larvae.* The author described experiments conducted to determine if the larvae are able to distinguish between various plants offered them as food, the result of these experiments proving that they are able to do so. The author is of the opinion that this is accomplished by means of an olfactory sense and locates the seat of this sense in certain minute pits scattered over various portions of the body, each pit connected with a sense cell. The structure and position of these organs were illustrated by charts and drawings.

In discussing this paper Mr. BUSCK congratulated Dr. McIndoo on his work and commented on the far-reaching possibilities it suggested in economic entomology, when we shall know enough about these supposed olfactory organs to tempt the codling moth away from the apple by a perfumed bait. He pointed out that the organs described by Dr. McIndoo were by no means a new discovery, but that at least those of the head were well known by lepidopterists and had all been carefully mapped out and named in connection with the parts of the head and the head setae. Their position relative to the setae is constant for each species and yields excellent generic and family characters, which enable determination merely from a larval head capsule.

Mr. Busck stated that he had hitherto considered the punctures as remnants of aborted setae and he still thought they must be considered such, modified to serve other senses than touch; the setae are sense-touch organs and have nerves running to their bases like the punctures. As one ground for this view he mentioned that certain of these supposed olfactory punctures, the ultra posterior punctures on the head, in some species bear a small hair and in others not.

Mr. Busck criticized and objected to Dr. McIndoo's arbitrary numbering of these punctures, starting on the thorax, continuing to the last abdominal segment, and ending with the head. He suggested as more rational and simpler to name them after the part of the body they are found on, and he thought it common sense to adopt the already existing names for the head punctures, which were used by Heinrich and himself and which were named after the head parts on which the punctures are situated.

Dr. PIERCE emphasized the bearing that papers like that under discussion have on taxonomy and economic entomology, and predicted that in future the determination of larvae by the minute characters of small fragments will be very generally possible.

In reply to a question, Dr. McIndoo stated that the organs that he had discussed are, in his opinion, used by the insect in selecting its host, but that this is theoretical. Dr. BAKER stated that similar organs in aphids undergo modification when the insects change to another host plant for a long series of generations, and that in some cases it is possible to determine from this what host plant a given individual developed on. Mr. Busck was of the opinion that the lepidoptera are not so susceptible to changes in host.

Notes and exhibition of specimens: Mr. CAUDELL exhibited a specimen of the Dectician *Capnobotes fuliginosus* Thomas that had fallen prey to the wasp *Palmodes praestans* Kohl, the interesting points being that the prey, itself probably predaceous, was killed by a wasp very much smaller than itself and that the wasp is the fourth known specimen of its species.

Mr. WOOD commented on the fact that living individuals of the woolly apple aphis are now present in aerial colonies and attributed this to the mild winter.

R. A. CUSHMAN, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

The Division of Mineral Resources of the U. S. Geological Survey has been reorganized, with Dr. EDSON S. BASTIN as geologist in charge. The section of metals will be in charge of G. F. LOUGHLIN; the section of nonmetals, other than fuels, R. W. STONE; the section of mineral fuels, C. E. LESHER; and the section of foreign resources, J. B. UMPLEBY. Mr. H. D. MCCASKEY, formerly chief of the Division, asked to be relieved of his administrative duties after the signing of the armistice in November, and will devote his time to special phases of American mineral resources.

Dr. SAMUEL S. ADAMS has been elected vice-president of the faculty of Georgetown University, to fill the vacancy caused by the death of Dr. Frank Baker.

Mr. A. D. CONLEY, associate physicist in the paper and textile laboratory of the Bureau of Standards, resigned from the Bureau in February to take up special research for the Wm. E. Cooper Company, of Baltimore, Maryland.

Miss AIDA M. DOYLE resigned from the Bureau of Chemistry in February and is now with E. I. du Pont de Nemours & Company, of Wilmington, Delaware.

Mr. J. D. EDWARDS, associate chemist, and Mr. A. D. BELL, assistant chemist, Bureau of Standards, expect to leave the Bureau in April to take up research at the laboratory recently organized by Dr. F. C. FRARY for the Aluminum Company of America, at Pittsburgh, Pennsylvania.

Dr. F. C. FRARY, formerly of the Oldbury Chemical Company of Niagara Falls, who has lately been engaged in war research, first in Washington and later at the Edgewood Arsenal of the Chemical Warfare Service, is organizing a research laboratory for the Aluminum Company of America, at Pittsburgh, Pennsylvania.

Dr. ALEŠ HRDLIČKA, Curator of Physical Anthropology in the U. S. National Museum, has been elected a member of the American Philosophical Society.

Mr. W. H. KEEN, formerly general manager of the Chemical Products Company and metallurgical superintendent of the Washington Steel and Ordnance Company, is now factory manager of the U. S. Copper Products Corporation, of Cleveland, Ohio.

Dr. WILLIS T. LEE is on leave of absence from the Geological Survey, and is now head of the Department of Geology and Director of the School of Engineering Geology in the University of Oklahoma, at Norman, Oklahoma.

Major J. H. MATHEWS, who has been with the Ordnance Department in Washington, has returned to the University of Wisconsin as professor of physical chemistry.

Prof. EARLE B. PHELPS, Professor of Chemistry at the Hygienic Laboratory, Public Health Service, resigned from the Service on March 1, 1919.

Professor EDWARD CHARLES PICKERING, professor of astronomy and director of the Harvard College Observatory, and a nonresident member of the ACADEMY, died at Cambridge on February 3, 1919, in his seventy-third year. Professor Pickering was born at Boston, Massachusetts, July 19, 1846. Excepting the years 1867–1876, during which he was Thayer Professor of Physics at the Massachusetts Institute of Technology, his entire academic career was spent at Harvard University. His astronomical work was especially concerned with the photometry and spectrum photography of the light of the stars. He was a member of the National Academy of Sciences, president of the Astronomical and Astrophysical Society of America, and a member of many American and foreign societies and academies. He had been a member of the ACADEMY since 1899, and was one of its nonresident vice-presidents in 1915 and 1916.

Mr. RICHARD L. TEMPLIN, formerly of the Bureau of Standards, is Engineer of Tests for the Aluminum Company of America, at New Kensington, Pennsylvania.

Mr. CARL VROOMAN, Assistant Secretary of Agriculture, resigned in January. Mr. Vrooman will remain for the present in Europe, where he had gone as a member of the Agricultural Commission sent out by the Department.

Mr. F. A. WERTZ, associate chemist at the Bureau of Standards, will leave the Bureau in March to take up research on varnishes and allied products for the Devoe and Raynolds Company, Incorporated, of New York City.

Brigadier General JOHN MOULDER WILSON, U. S. A., retired, died at his home, 1773 Massachusetts Avenue, on February 1, 1919, at the age of 81. General Wilson first came to Washington in 1885, as superintendent of buildings and grounds, in which capacity he had charge of the construction or completion of many of the now familiar structures of the city. He became Chief of Engineers in 1897, and retired in 1903. He had been for the past fifteen years a member of the Board of Managers of the National Geographic Society.